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# Request for grant of a Patent

The Patent Office

**Form 1/77**

**Patents Act 1977**

## ❶ Title of invention

1 Please give the title of the invention: THE IMPLEMENTATION OF TRICK-PLAY MODES FOR PRE-ENCODED VIDEO

## ❷ Applicant's details

*❷ Do not give trading styles, for example, 'Trading as XYZ company', nationality or former names, for example, 'formerly (known as) ABC Ltd' as these are not required.*

☐ **First or only applicant**

2a If you are applying as a corporate body please give:

Corporate name

THOMSON CONSUMER ELECTRONICS, INC.

Country *(and State of incorporation, if appropriate)*: DELAWARE UNITED STATES OF AMERICA

2b If you are applying as an individual or one of a partnership please give in full

Surname

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2c **In all cases**, please give the following details:

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Indiana 46206

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Country: United States of America

ADP number *(if known)*: 6044762001

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3a Have you appointed an agent to deal with your application?

Yes [X] No [ ] ➡ ***go to 3b***

***please give details below***

Agent's name ~~RICHARD W PRATT~~

Agent's address ~~London Patent Operation~~
~~G.E. Technical Services Co. Inc.~~
~~Essex House~~
~~12/13 Essex Street~~
~~London~~

WILLIAMS, POWELL & ASSOC
34 TAVISTOCK STREET
LONDON WC2E 7PB

Postcode ~~WC2R 3AA~~

Agent's ADP number 3954005 ~~Lf~~ 51/17 4/3/96

*3b: If you have appointed an agent, all correspondence concerning your application will be sent to the agent's United Kingdom address*

3b If you have not appointed an agent please give a name and address in the United Kingdom to which all correspondence will be sent:

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ADP number *(if known)*

## ❹ Reference number

4 Agent's or applicant's reference number *(if applicable)* — RCA 87865/4401

## ❺ Claiming an earlier application date

*Please mark correct box*

5 Are you claiming that this application be treated as having been filed on the date of filing of an earlier application?

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## 7 Inventorship

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8 *Please supply duplicates of claim(s), abstract, description and drawing(s).*

## 8 Checklist

8a Please fill in the number of sheets for each of the following types of document contained in this application.

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| Claim(s) | – | Description | 8 |
| Abstract | – | Drawing(s) | – |

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| Patents Form 7/77 – Statement of Inventorship and Right to Grant *(please state how many)* | 1 |
| Patents Form 9/77 – Preliminary Examination/Search | |
| Patents Form 10/77 – Request for Substantive Examination | |

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# THE IMPLEMENTATION OF TRICK-PLAY MODES FOR PRE-ENCODED VIDEO

## Introduction

The implementation of trick-play modes within digital video systems is a problem which is becoming more important as digital video-based systems enter the marketplace. Video CDs, video on demand (VOD) and other similar systems are starting to emerge as new future consumer products; and many of these products are looking to compete with the VHS tape market as providers of feature-length movies to the consumer. However, unlike existing analog-based systems, digital video systems pose more of a challenge when it comes to providing trick-play modes (fast-forward, fast-reverse, freeze-frame, etc.).

MPEG is fast becoming the standard digital compression format for the storage and transmission of digital video material. Unfortunately, the processing required to produce a trick-play stream at, for example 10 to 30 times normal speed, from a single normal-speed MPEG video stream is relatively complex and expensive. As a result, a method has been developed which provides trick-play modes by the use of separate video streams for various fast-forward and fast-reverse speeds. These various video streams are switched between when the user desires to implement these modes. This trick-play method been developed based on MPEG-1 and MPEG-2 encoded video material. However, this trick-play method may be applied to any digital or analog video system that require the implementation of trick-play modes,

## Overview

The basis of this method is that separate video streams are employed to provide different trick-play modes. A single stream is used for normal play and then other streams are used to provide a variety of fast-forward and fast-reverse modes. The image streams which provide the trick-play feature may not be encoded at the same bit-rate, and may not have the same resolution as the original image stream. The use of a significantly lower bit-rate and/or resolution for encoding trick-play image streams may offer savings benefits when storage space and/or transmission costs are considered. In addition, human visual perception may also allow the reduction of resolution during trick-play video browsing.

## Description

As already mentioned, sections of this method may be applied to various forms of video material (analog or digital and encoded in a variety of ways). However, in the remainder of this description, it will be assumed that the trick-play streams are encoded

in an MPEG format. During this description of the method, the following parameters will also be assumed:

- There is a single normal-play (normal speed) MPEG video stream.
- There are two required fast-forward streams, (7x and 21x normal speed).
- There are two required fast-reverse streams (negative 7x and 21x normal speed).

Note: This is only one example of a possible configuration and will suffice as an example for explanation purposes. However, this method may be applied equally effectively to an infinite number of configurations.

For the above configuration, five separate MPEG-encoded streams are required. These streams are completely independent and may be of varying bit-rates and/or varying display resolutions. For example, one possible trade-off between quality and efficiency is illustrated in Table 1 below. In this case, the trick-play streams employ a lower resolution (352 x 480 pixels) and a lower bit-rate (1.5 Mbps) than the normal-play stream (704 x 480 at 4.0 Mbps). Such a trade-off is very reasonable since very high spatial picture quality may not be required for trick-play material. These trade offs resultin more efficient storage utilization. The total storage overhead (extra storage capacity required to store all forward and reverse trick-play streams in addition to the normal-play stream) is still less than 15% (the overhead can be calculated by summing the bit-rate over the playing speed, and for this particular example is equal to 14.3% of the space required for the normal play stream).

| STREAM | BIT-RATE (Mbps) | RESOLUTION |
|---|---|---|
| Normal-play | 4.00 Mbps | 704x480 |
| 7x forward | 1.50 Mbps | 352x240 |
| 21x forward | 1.50 Mbps | 352x240 |
| 7x reverse | 1.50 Mbps | 352x240 |
| 21x reverse | 1.50 Mbps | 352x240 |

*Table 1: An example of distributing bit-rate and resolution changes among trick-play streams.*

As the video material is played back from the video server to the decoder, the server would switch between the various streams responsive to instructions from the user. For example, if the user chose to fast-forward through the material at the highest speed, then the server would jump from within the normal-play stream to the appropriate point within the 21x fast-forward stream and continue playing. Each of the trick-play streams (as well as the normal-play stream) would require a relatively uniform and short group of

pictures (GOP) size of, for example, half a second. This would allow a maximum of 0.25 seconds of visual continuity error when switching decoding from one bit-stream to another.

An important part of the overall system is the method for determining switching entry points between the different image streams. For example, during "playback" of one stream a user may wish to switch to another stream. This switch requires calculation of the exact location in the new stream (to a byte accurate level) that the decoder should begin to play from. The very basic steps to determine this "entry point" are as follows:

1. Determine the current byte offset (and hence the current frame) in the current file.
2. Determine the new frame to switch to in the new file.
3. Determine the byte offset in the new file..

Step 2 is complicated by the fact that, for MPEG streams, the entry points into a new stream are limited to those points where a sequence_header exists. This is typically at the beginning of a group of pictures (GOP). It is further complicated by the fact that the duration (in real display time) of a GOP is not always constant (even if the number of frames in a GOP is constant). This is because it is possible to repeat fields (or frames) in an MPEG sequence, which effectively means that more final 'displayed' frames can be produced by a single GOP than there are coded 'pictures' in the GOP.

An example of stream switching is illustrated in FIG. 1. In this case, the original or normal speed stream is playing, and two Trick Play streams are provided at 2x and 10x normal speed. The Trick Play speeds of 2 and 10 times are selected for illustration simplicity. At the instant of Trick Play selection (switching time) the normal play stream is at frame number 20. Possible entry points into each of the three image streams are determined by sequence headers which are indicated by the darkened frames. The "best fit" frames which can be switched to are indicated by the arrowhead line which links possible entry points into the various video streams. The "ideal" or desired entry points, in terms of the users visual continuity, are indicated by horizontally shaded frames. Note that these "ideal" points are not necessarily calculated simply from (current frame in normal sequence)/(trickplay stream speed) due to the complications described above. In each case, the actual frame switched to is a "best fit" possible entry frame which is closest in time to the users desired or "ideal" frame.

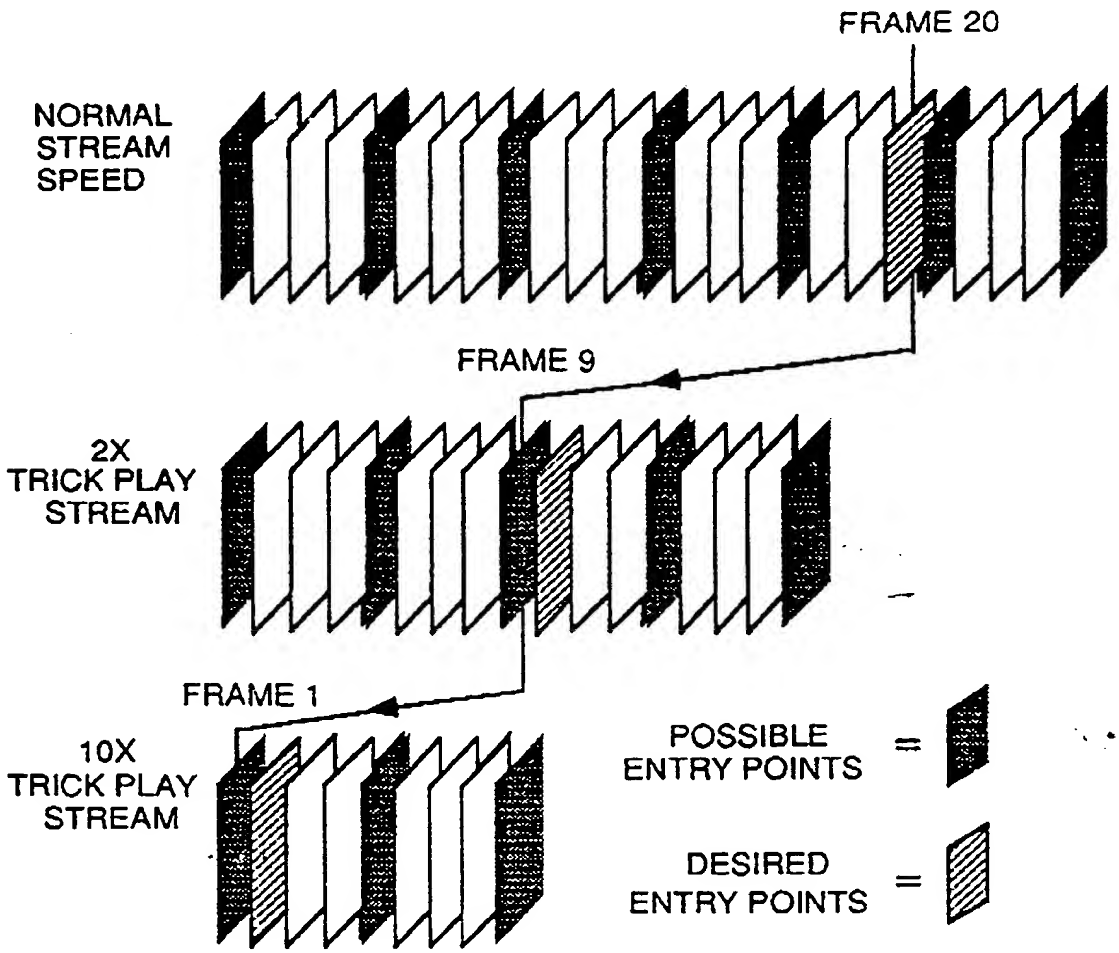


**FIG.1 CHANGING BETWEEN NORMAL & TRICK PLAY MPEG VIDEO STREAMS**

From the illustration in FIG. 1, the decision of which frame to switch to appears to be obvious. However, from an algorithmic point of view this is far from trivial. An important part of the overall system is the method of determining the switching points between the different streams. To accomplish this function, a look-up table (LUT) is employed. The functionality and arrangement of this table is described below. Table 2 describes the general layout of the LUT.

```
[number_of_tables]
[Table_number] {file_name} <bit_rate Mbps> [num_gops]
   [num_frames] [gop_size] [1st_gop_size] [speed]
[gop number] [file byte offset]
[gop number] [file byte offset]
[gop number] [file byte offset]
.
.     Repeated [num_gops] times
.
[gop number] [file byte offset]
[gop number] [file byte offset]
[gop number] [file byte offset]
.
.          Repeat all of above (except for the first line)
   [number_of_tables] times
.
```

*Table 2: Look-up Table layout*

*The items in Table 2 are described below:*

*[] denotes an integer value*
*<> denotes a floating point value*
*{} denotes a text string*

*[number_of_tables]*
*The number of look-up tables in the file (same as the number of bitstreams). In most cases there is one normal play stream, one 7x stream, one -7x stream, one 21x stream and one -21x stream. Therefore [number_of_tables] would be 5.*

*[Table_number]*
*This is a number which is associated with the ordering of the streams. This number must be between 0 and [number_of_tables]-1. [Table_number] also shows the order of the streams (from fastest reverse to fastest forward).*

*{file_name}*
*The name of the muxed MPEG stream.*

*<bit_rate>*
*The rate (in Mbits/second) of the muxed MPEG stream (including transport layer overhead).*

*[num_gops]*
*The number of GOPs in the video stream.*

*[num_frames]*
*The total number of frames (displayed) in the MPEG video stream (before any pulldown).*

*[gop_size]*
*The GOP size (in displayed frames - taking into account 3/2 pulldown if necessary).*

*[1st_gop_size]*
*Size (in displayed frames) of the first GOP. Usually this will be [gop_size]-N+1.*

*[speed]*
*Speed of the trick-play stream (including sign). i.e. -7 for the negative 7x stream.*

Such an LUT is stored in the system memory during playback of the video material. When the user changes from one speed to another, the information in the LUT is used to start decoding the new stream from the correct place. The information in the LUT is needed for this purpose along with the current offset (in bytes) in the bit-stream currently being played.

To switch streams the current GOP is determined from the current file offset. This is accomplished by looking through the LUT to find the GOP start point which corresponds to the current offset (see Table 2). Once this is known, the new GOP is calculated from the old GOP number, given the old and new speeds, GOP size, frame number and first GOP size. The appropriate LUT is then used to find the file offset (in the new file) corresponding to the calculated new GOP. The new stream can then be played starting at this new offset point. The relative simplicity of this system results in efficient switching between different streams. However, this real time calculation method is based on two assumptions, namely that the stream contains GOPs of the same size and that material derived from 3:2 pull down telecine not be edited to disturb the frame sequence.

In view of these two potential variables, and without knowing in advance exactly how many frames will be produced by a GOP, for example when decoding 3:2 pull down material, it may be difficult to accurately determine, with real time calculation, exactly where to enter a second image stream. Thus the real time calculation method has been utilized in a further method which calculates and constructs off line, i.e. not in real time, multiple look-up tables (LUT) which contain all possible entry points into the various play and trick play streams. Thus complete 'time-maps' of the new streams are available (since even if the current "real-time" frame number is known, you cannot calculate which picture number in the new stream

corresponds to the same point in time). In addition to this practical problem, it is also advantageous to allow a user to fine tune or modify, the stream switching delay and accuracy independently from the actual switching software. For example a user may, in the interest of continuity of entertainment, opt to always join the new image stream 1/2 or 1 second prior to the departure point in the fist stream. Hence the software never requires modification even when a switching scheduling change is necessary. For these reasons, a generic LUT format has been developed which allows the entry point calculation and tuning of stream switching delays to be done independently from the software which employs the tables. A conceptual illustration of 2 LUT sets is shown in FIG. 2 for transitions from play speed and 7 times play speed. Similar sets of tables are required for transitions from 21X, -7X and -21X trick play speeds.

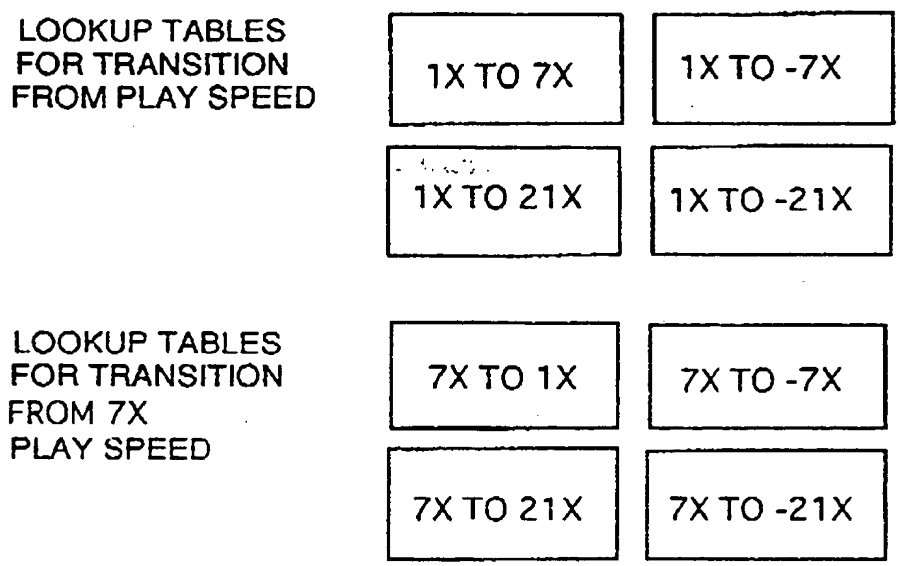


FIG. 2 TRICK PLAY LOOKUP TABLES

The basis of the LUT-based switching method is as follows: In a system with N streams, comprising a normal play stream and various trickplay streams, it is desirable to provide the ability to switch from any stream to any other stream. Hence for each stream N-1 tables of (byte-offset, byte-offset) pairs are required. The first offset in the pair corresponds to the point or location being viewed in the current stream. The second offset refers to the same point in time (program location) in the stream to be switched to. The general layout of these LUTs is illustrated in Table 2, where ["from" byte offset N] is the offset (in bytes) location in the current file (video stream) to be switched from, ["to" byte offset N] is the offset (in bytes) where decoding should start in the new file (video stream) that is being switched to, and [num_pairs] is the number of pairs of switching coordinates in the file.

The number of pairs of number in each table depends only on the required precision when switching streams (fewer pairs save storage space but provide less accuracy). However, the upper limit for accuracy is still governed by the number of GOPs (and hence, the number of possible entry points) in the stream being switched to.

```
["from" byte offset 1] ["to" byte offset 1]
["from" byte offset 2] ["to" byte offset 2]
["from" byte offset 3] ["to" byte offset 3]
.
.      Repeated [num_pairs] times
.
["from" byte offset <num_pairs-1>] ["to" byte offset <num_pairs-1>]
["from" byte offset <num_pairs>] ["to" byte offset <num_pairs>]
```

*Table 2: Look-up Table layout*

Hence, for a system employing N video streams, stream S1 will use (N-1) tables. These tables are used for switching from stream S1 to S2 (table T_1_2), S1 to S3 (T_1_3), S1 to S4 (T_1_4)....... and S1 to SN (T_1_N). For example, if a current image location is at offset O1 in stream S1 and switching to stream S3 is required, the following operation is required:

1) Find the closest (in time) "from" offset in table S_1_3.
2) Read the corresponding "to" offset from the same table.
3) Start decoding stream S3 from the "to" offset value read.

The overhead from these tables is still very minor compared to the storage space required for the video streams themselves. The simple interface and use of these tables by the control software represents very little processing overhead when switching streams. In addition, all control and fine tuning of the switching procedure (accuracy, timing, etc.) can be controlled by altering the values and number of entries in the tables themselves without requiring access to the software (which may not be available to a user).

## Conclusions

This document has described methods for implementing trick-play modes for pre-encoded video material on a variety of media platforms (e.g. video servers and digital video disk). These methods allow the use of separate trick-play streams which may have differing resolutions and/or bit-rates from the original encoded video stream. These schemes for switching between the various coded video streams are based on the use of look-up tables (LUT) which provide an efficient, accurate and flexible method of switching between streams.

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